FAA-E-2376
January 7, 1969

# DEPARTMENT OF TRANSPORTATION
# FEDERAL AVIATION ADMINISTRATION SPECIFICATION

MULTIPLEX SYSTEM, VOICE/DATA, COMMERCIAL TYPE

## 1. SCOPE

1.1 Scope.- The equipment described herein is a voice/data twelve-channel carrier system expandable to 600 channels. High quality, commercially produced equipment will be procured under this specification, supplied in accordance with the contract schedule.

## 2. APPLICABLE DOCUMENTS

2.1 Military specification.- The following Military specification, of the issue in effect on date of the invitation for bids or request for proposals, forms a part of this specification:

| | |
|---|---|
| MIL-E-17555 | Electronic and Electrical Equipment and Associated Repair Parts, Preparation for delivery of |

2.2 FAA standard.-

| | |
|---|---|
| FAA-STD-013 | Quality Control Program Requirements |

(Copies of this specification and the applicable MIL specification may be obtained from the Federal Aviation Administration, Washington, D. C. 20590 Attention: Contracting Officer. Requests should fully identify material desired, i.e., specification numbers, dates, amendment numbers, complete drawings numbers; also requests should state the contract involved or other use to be made of the requested material. Note that requests for MIL specifications will be forwarded to the Military supply depot for filling, hence ample time should be allowed.)

## 3. REQUIREMENTS

3.1 Equipment to be furnished by the contractor.- Each equipment terminal furnished by the contractor shall be complete in accordance with all specification requirements. Commercial instruction books meeting the requirements of 3.3.10 shall be furnished in accordance with the contract schedule.

3.2 General.- Insofar as the contract schedule may require, the carrier terminal shall be complete and ready for operation and shall consist of the following: equipment rack, terminal blocks, wiring, and patch panel; and shall include full duplex voice drop equipment, full duplex carrier equipment, power supply equipment. When called for in the contract schedule, line extension equipment shall be furnished.

3.3 Construction.- The equipment shall be metal enclosed and mounted in a floor mounting 96-inch, channel-type rack. Blank panels shall be supplied to fill all unused rack space. Wiring ducts shall have metal covers.

3.3.1 Accessibility.- All controls, test points, monitors, and maintenance shall be accessible from the front of the rack.

3.3.2 Interchangeability.- All parts having the same manufacturer's model and part number shall be completely interchangeable.

3.3.3 Plug-in units.- All plug-in units or slide in drawers shall have guides or slots through the full length of the component travel; all connectors shall have alignment guides.

3.3.4 Equipment extenders.- One universal equipment extender shall be furnished with each carrier terminal. Additional extenders shall be furnished if called for in the contract schedule.

3.3.5 Finish.- The equipment shall be finished in accordance with Federal Standard 595, color 16376.

3.3.6 Equipment identification.- All major terminal equipment units shall carry the manufacturer's name and type number.

3.3.7 Coordination.- Pilot frequencies and transmission levels shall be compatible with either CCITT or Western Electric "L" Systems on an end-to-end and on an intra-office basis, and be furnished as called for in the contract schedule.

3.3.8 Jack-field panels.- Jack-field panels shall be furnished with each carrier terminal, wired to both the VF and HF input and output circuits, for monitoring and testing the system called for in the contract schedule.

3.3.9 Power supplies.- Power supplies shall be provided as called for in the contract schedule.

3.3.10 Instruction book.- Commercial instruction books shall be furnished which fully describe the equipment and as a minimum contain the following:

Manufacturer's name and address
General description
Theory of operation
Operating instructions
Schematic diagrams
Wiring diagrams
Parts Lists
Installation and maintenance instructions
Guarantee

3.4 Design.- The equipment shall be completely solid-state design.

3.5 Environmental conditions.-

| | |
|---|---|
| Temperature | $0^{\circ}C$ to $+50^{\circ}C$ |
| Relative humidity | 10% to 80% |
| Elevation | 0 to 15,000 feet above sea level |

3.6 Power source.-

| | |
|---|---|
| AC line voltage | 105 V to 130 V |
| AC line frequency | 58 to 62 Hz |
| DC supply voltage | 46 to 52 V DC |

The system shall operate from normal DC supply voltages ranging from -46V to -52V without degradation, and it must be able to operate from emergency DC supply voltages ranging from -42V to -56V. When called for in the contract schedule, a DC power supply shall be furnished having sufficient capacity for continuous operation of the equipment.

3.7 Modulation scheme.- This frequency division multiplexing system shall use a three-stage, single-sideband, suppressed carrier modulation scheme to combine up to a maximum of 600 voice-frequency channels of nominal 4 KHz bandwidth into a single baseband output. The lower sideband shall be selected at each modulation stage except that Supergroup 2 shall be placed in the line-frequency spectrum after the second stage of modulation and that Supergroup 9 shall be an upper sideband in Western Electric "L" Coordinated Systems.

In the first stage, each voice frequency input signal shall modulate one of 12 channel carrier frequencies to provide a basic 12-channel group in the 60 to 108 KHz frequency range.

In the second stage of modulation, five of these 12-channel groups shall modulate five group carrier frequencies to produce a basic 60-channel supergroup in the 312 to 552 KHz frequency range.

In the third stage of modulation, up to ten of these 60-channel supergroups comprising the baseband shall be placed on the line in the 60-2799 KHz frequency range for "L" coordinated systems and in the 60-2540 KHz frequency range for CCITT coordinated systems. This shall be achieved by placing Supergroup 2 on the line without modulation and by direct modulation of the nine remaining supergroups with the appropriate supergroup carrier frequencies.

Demodulation shall be accomplished by reversing the modulation process.

3.8 Interconnections.- Group and Supergroup connector filters shall be available to connect groups and supergroups back-to-back without demodulating to voice frequencies.

3.9 Pilots.- A group pilot shall be provided at 84.08, 92.0, or 104.08 KHz for in-service monitoring of system levels and performance. A supergroup pilot, a result of modulation of group pilot, shall appear at 315.92, 411.92, 424, or 431.92 KHz. A line pilot shall be provided at 32, 60, 64, 308, or 564 KHz for frequency synchronization and monitoring.

The group pilot shall be 104.08 KHz, unless a different frequency is called for in the contract schedule and the supergroup frequency shall be 315.92 KHz.

3.10 Regulation.- System regulation equipment shall be available to be inserted in the receive path, either between the channel and group equipment to provide group regulation, or between the group and supergroup equipment to provide supergroup regulation. This regulation equipment shall sense changes in the group or supergroup pilot level and automatically adjust the receive signal level.

The regulation range referred to the nominal input level shall be $\pm 6$ dB while providing output regulation of $\pm 0.3$ dB. The regulator shall accommodate a pilot frequency error of $\pm 5$ Hz, and, upon loss of the pilot or a step decrease of at least 14 dB, a passive, zero gain standby shall be provided as a straight-through connection.

3.11 Signalling.- Either 2600 Hz in-band signalling or 3825 Hz out-of-band signalling shall be available. E & M signalling shall be available in either arrangement, and loop-dial and foreign exchange options shall be available with an in-band signalling arrangement.

3.12 Frequency supply.- All carrier frequencies shall be derived from a crystal-controlled, temperature-compensated master oscillator. A crystal oven employing proportional control shall be used for temperature compensation. The oven controls shall use only thermistors for temperature sensing--thermostats are not an acceptable alternative.

Harmonic generators used to develop carrier frequencies shall be designed so that no pulse width adjustments are required.

3.12.1 Stability.- The frequency of the master oscillator shall not vary more than two parts in ten million in any three-month period.

3.13 Synchronization.- The end-to-end frequency error through the worst channel of a non-synchronized 600-channel system shall not exceed 1 Hz over any three-month period.

Absolute synchronization (zero end-to-end frequency error) shall be available using master-slave terminal arrangements.

3.14 Redundancy.- All active equipment in the transmission path common to more than 12 channels shall be provided with parallel standby circuitry.

3.15 Alarms.- The operation of all redundant amplifiers common to more than 12 channels that is individually sensed at all times--fuse alarm alone is not adequate. A minor alarm indication shall be provided upon failure of either amplifier and a major alarm indication shall be provided upon failure of both amplifiers.

The group alarm equipment shall provide alarm indications at both ends of a system for any transmission failure between the group transmit input and group receive output terminals in either direction. One terminal shall be available to be unattended with all group alarms received at the attended station, and the alarm equipment shall be able to be reset automatically at either terminal.

Signalling make-busy equipment shall be available to be activated by group alarm indications to stop ticketing on circuits to use and to busy out all circuits of a defective group to prevent subscribers from dialing into a dead circuit. The signalling make-busy equipment shall incorporate a 10 to 20 second delay to guard against operation during short-term line faults.

Frequency alarms shall be provided to indicate excessive frequency differences between the master oscillators at any one station or between stations.

3.16 Channel bank requirements.-

3.16.1 Equipment parameters.-

3.16.1.1 Impedance.- The VF transmit and receive impedances for a 4-wire drop shall be 600 ohms balanced; for two wire drops 600 ohm and 900 ohm balanced impedance arrangements shall be available.

The HF transmit and receive impedances shall be either 130 ohms balanced or 75 ohms unbalanced.

The pilot and carrier input and output impedances shall be 130 ohms balanced.

3.16.1.2 Transmission levels.- The VF transmit level shall be either -16 dBm or -13 dBm for a 4-wire drop and 0 dBm for a 2-wire drop. The VF receive level shall be variable over a range of 0 dBm to +10 dBm for a 4-wire drop and maximum of -2 dBm for a 2-wire drop.

The HF levels shall be -42 dBm transmit and -5 dBm receive for US Coordinated Systems or -37 dBm transmit and -8 dBm receive for CCITT Coordinated Systems.

The carrier level shall be 0 dBm per duplex channel carrier. The signalling tone level at the HF transmit terminals shall be -20 dBm0. With in-band signalling, the signalling tone shall be at -8 dBm0 during pulsing.

A group pilot shall have the line level adjustable to -20 dBm0 to $\pm$0.1 dB. The transmit pilot input level will be -45 dBm, and the receive pilot output level will be either -32 or -35 dBm.

3.17 Operating specifications.-

3.17.1 Frequency response.- In-Band Signalling: The end-to-end, 4-wire frequency response of the worst channel relative to 1000 Hz shall be within +0.5 dB and -3.0 dB for frequencies ranging from 250 Hz to 3400 Hz.

Out-of-Band Signalling: The end-to-end, 4-wire frequency response of the worst channel relative to 1000 Hz shall be within +0.5 dB and -3.0 dB for frequencies ranging from 300 Hz to 3550 Hz when the temperature is within a range of +10°C to +40°C.

3.17.2 Relative envelope delay.- The maximum delay is specified as the maximum delay relative to the point of minimum delay. The minimum delay refers to the absolute delay at midband.

3.17.3 Unequalized delay.- In-Band Signalling: The maximum, unequalized envelope delay in the worst channel of a looped-back, in-band signalling channel bank shall be 220 microseconds for frequencies ranging from 1000 Hz to 2600 Hz and 450 microseconds for frequencies ranging from 750 Hz to 2800 Hz.

Out-of-Band Signalling: The maximum, unequalized envelope delay in the worst channel of a looped-back, out-of-band signalling channel bank shall be 160 microseconds for frequencies ranging from 1400 Hz to 2600 Hz and 450 microseconds for frequencies ranging from 1000 Hz to 2900 Hz.

3.16.1.2 Transmission levels.- The VF transmit level shall be either -16 dBm or -13 dBm for a 4-wire drop and 0 dBm for a 2-wire drop. The VF receive level shall be variable over a range of 0 dBm to +10 dBm for a 4-wire drop and maximum of -2 dBm for a 2-wire drop.

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3.17.8 Sidetone.- The sidetone measured at the VF receive drop when the test tone is applied to the VF transmit of the same channel and the HF lines are terminated in their characteristic impedances shall be -48 dBm0 or better.

3.17.9 Carrier leak.- The carrier leak of any channel shall not exceed -25 dBm0 for in-band or out-of-band signalling channel banks.

3.17.10 Harmonic distortion.- The total harmonic distortion for a 0 dBm0 test tone shall not exceed 1%.

3.17.11 Noise loading.- Out-of-Band Signalling: When 11 channels in a channel bank are loaded with band-limited white noise (300 to 3400 Hz) at a level of -7.5 dBm0 per channel and the channel is looped back, the noise from all sources into the quiet channel shall be less than 12.5 dBa0, F1A weighted.

3.18 Group bank requirements.-

3.18.1 Equipment parameters.-

3.18.1.1 Impedance.- The group drop impedances shall be either 75 ohm unbalanced or 130 ohm balanced. The group bank line impedances shall be 75 ohm unbalanced. The group carrier impedance shall be 75 ohm unbalanced, and the group pilot impedances shall be 130 ohm balanced.

3.18.1.2 Transmission levels.- The group drop levels shall be either -42 dBm or -37 dBm for the transmit input level and either -5 dBm or -8 dBm for the receive output level.

The line levels shall be either -25 dBm or -35 dBm for the HF transmit level and either -28 dBm or -30 dBm for the HF receive level.

The transmit pilot input level shall be -45 dBm, and receive pilot output level will be either -32 dBm or -35 dBm.

3.18.2 Operating specifications.-

3.18.2.1 Frequency response.- The group frequency response over the 60 to 108 KHz frequency range shall be $\pm$0.5 dB when the group is looped at the HF side of the group bank.

3.18.2.2 Relative envelope delay.- The relative envelope delay distortion added to a channel (600 Hz to 3100 Hz) when the group is looped at the HF side of the group bank shall be less than 25 microseconds when a pilot elimination filter is not used.

3.18.2.3 Idle noise.- The idle noise contribution of the group equipment measured at the channel VF receive drop shall be less than 10 dBa0, F1A weighted, when the group is looped at the HF side of the group bank.

3.18.2.4 Loaded noise.- The loaded noise contribution of the group equipment measured at a channel VF receive shall be 14.5 dBa0 or less, F1A weighted, when all groups (except for the measured channel) are loaded with random noise at +4 dBm0.

3.18.2.5 Crosstalk and sidetone.- Both group-to-group crosstalk and sidetone coupling shall be attenuated more than 70 dB.

3.18.2.6 Return loss.- The return loss measured at the group drop terminals shall be 20 dB or greater for frequencies ranging from 60-108 KHz.

The return loss measured at the group pilot input and output terminals shall be 20 dB or greater.

3.18.2.7 Carrier leak.- The carrier leak shall be -35 dBm0 or less per group line side and -17 dBm0 or less per group drop side.

3.19 Supergroup bank requirements.-

3.19.1 Equipment parameters.-

3.19.1.1 Impedance.- The supergroup drop, carrier, and pilot impedances shall be 75 ohms unbalanced. The supergroup line impedances shall be either 75 ohms unbalanced or 124 ohms balanced.

3.19.1.2 Transmission levels.- The supergroup drop levels will be either -25 dBm or -35 dBm for the supergroup transmit input and either -28 dBm or -30 dBm for the supergroup receive output.

The supergroup combiner shall have an HF transmit level of either -40 or -50 dBm, and it shall accept an HF receive level in the -10 to -25 dBm range.

Facilities shall be available to insert a supergroup pilot at an input level of -15.5 dBm for a supergroup transmit input level of -25 dBm, and to remove a supergroup pilot at an output level of -67 dBm for a supergroup receive output level of -28 dBm. With these levels, the pilot shall be -20 dBm0.

3.19.2 Operating specifications.-

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3.18.2.4 Loaded noise.- The loaded noise contribution of the group equipment measured at a channel VF receive shall be 14.5 dBa0 or less, F1A weighted, when all groups (except for the measured channel) are loaded with random noise at +4 dBm0.

3.18.2.5 Crosstalk and sidetone.- Both group-to-group crosstalk and sidetone coupling shall be attenuated more than 70 dB.

3.18.2.6 Return loss.- The return loss measured at the group drop terminals shall be 20 dB or greater for frequencies ranging from 60-108 KHz.

The return loss measured at the group pilot input and output terminals shall be 20 dB or greater.

3.18.2.7 Carrier leak.- The carrier leak shall be -35 dBm0 or less per group line side and -17 dBm0 or less per group drop side.

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3.19.2 Operating specifications.-

3.20.2.4 Loaded noise.- The noise contribution of the line equipment shall be 11 dBa0 or less when the system is loaded at +17 dBm0 and the output level is -15 dBm.

3.20.2.5 Harmonic distortion.- The second harmonic distortion shall be -58 dB or better, and the third harmonic distortion shall be -63 dB or better relative to a one megahertz amplifier output signal at +9 dBm.

## 4. QUALITY ASSURANCE PROVISIONS

4.1 General.- The contractor shall be responsible for conducting all inspection and testing to assure product conformance with the requirements of this specification and shall utilize, for this purpose, a quality control program in accordance with FAA-STD-013.

## 5. PREPARATION FOR DELIVERY

5.1 Packing.- See MIL-E-17555.

5.2 Marking.- Each package shall be clearly marked so that it can be readily identified.

## 6. NOTES

6.1 None.

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